CHEMISTRY

IN THE

UNITED STATES DEPARTMENT OF AGRICULTURE

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FOREWORD

Without the assistance of chemistry it is quite possible that modern agriculture would be little ahead of the crop and animal growing practices in use 300 years ago. To be sure, some progress was made with only the most superficial knowledge of the parts played by the principal elements, but the development of chemistry was needed to put empirical practices on an understandable basis and open the way for sure and steady improvement in the feeding of both plants and animals and in a host of other problems touching agriculture directly and indirectly. Since its establishment in 1862, the United States Department of Agriculture has been interested in chemical work; in fact, from the very beginning there was a division of chemistry, with a staff of four or five men. It finally developed into a bureau, and in a reorganization effective July 1, 1927, was consolidated with the Bureau of Soils, the fixed-nitrogen research laboratory, and a section or the Bureau of Plant Industry to form the Bureau of Chemistry and Soils. It now concerns itself with problems not even on the horizon of its experience 50 years ago. Not only this bureau but 8 or 10 others of the department now depend upon chemists in small or great degree to apply their solvents to obstacles in the way of better living conditions. The problems not only of agriculture but a thousand and one others, of the consumer and the manufacturer, are attacked. In other words, the department's concern is not limited to farm products while they are still on the farm, but follows them to their destination. Furthermore, it is concerned with agricultural materials even before they reach the farm.

A few examples will indicate the scope of the activities based on chemistry. Sources of fertilizer are in-

vestigated, and processes of manufacture are developed to provide better and cheaper materials for crop production. Materials offered by manufacturers for the control of diseases and pests are tested in order that the prospective user may not be defrauded. Better methods of making and handling dairy products are originated and introduced. Investigations are made to find processes for putting up new fruits and vegetables or to develop better methods for preserving well-known products. Manufacturers have been given more effective ways for making sirup, paper, and dyes and for preparing leather, and equipment has been designed to protect many industries from dust explosions. The medical profession has been provided with better means for fighting some widespread and destructive diseases. Efforts are being made to find the composition of the natural plant odors which attract insects, a possible way to fight pests. Lures for attracting predatory animals have been discovered and used. New facts about vitamins have been brought to light, and there have been recent revelations regarding the fundamental composition of soils.

In the Department of Agriculture the chemist is tilling many productive fields, and new discoveries are continually opening other opportunities where he may be of greater service to people engaged in all sorts of activities. The chemical work being done by various branches of the department is described briefly in the following pages.

BUREAU OF CHEMISTRY AND SOILS

The Bureau of Chemistry and Soils studies chemical problems pertaining to agriculture and to industries that utilize agricultural products. Its investigational activities fall into the following groups.

Biological Stains

Biological stains are indispensable in many lines of biological and histological research. A great deal of work

has been done on the standardization of these materials in order that the users may obtain the same results from successive batches of the same stain. It has been found that in a number of stains the variation is owing to the presence of quantities of impurities that are related to the main component of the stain, in many cases the staining value of the product being due to these secondary dyes rather than to the color that gives the stain its name. This is especially true of methylene blue. A number of subsidiary dyes that occur in methylene blue are now available as separate stains.

Syntheses have been made of a number of fuchsins with a view to choosing the one that will give the best results, both from the point of view of the stain technic itself and from that of the fastness of the color. In this work the spectrophotometer is used to a large extent.

Catalytic Oxidations

The first catalytic oxidation which was successfully carried out in the color laboratory was the oxidation of naphthalene to phthalic anhydride. Since then many problems of this kind have been studied with varying degrees of success. At present the vapor phase oxidation of p-cymene is the subject under investigation. This by-product, also known as "sulphite turpentine" is now produced in large quantities in the sulphite process for paper pulp, and it is believed that if sufficient uses for this material are found its production can be so cheapened that it can be made available at a reasonable price.

Carbohydrates

The carbohydrate division seeks to promote by chemical investigation the more effective production and utilization of sugar- and starch-producing crops. Attention is given to various carbohydrate products, such as cane and beet sugar, cane and sorghum sirups, maple products, corn sugar, corn sirup, starches, starch conversion products, and honey.

A systematic study is being made of the carbohydrate constituents of various plants that have not been adequately investigated from this standpoint. The information obtained in this investigation may lead to the more profitable utilization of plants at present cultivated, and may also indicate possible uses for plants that are not at present under cultivation or that are not extensively cultivated. This information may also result in more effective utilization of by-products.

In connection with these carbohydrate investigations, considerable attention is being given to a study of the colloids in plant juices and to methods for their approximate quantitative estimation. It is now known that the removal of colloidal material is an important part of processes for clarifying cane and beet juices and starch conversion liquors before crystallization of sugar. A study of the properties and behavior of these colloidal substances is being made with the idea of using this information as a basis for improving present processes.

Methods of controlling the clarification of beet and cane juices have been studied. Means have been developed whereby this extremely important process may be governed automatically. The operation is based on the hydrogen-ion concentration of the treated juice, since the pH value is a determining factor in clarification.

Recent investigations in this laboratory have shown that the poor refining quality of certain raw cane sugars is owing not only to salts but to colloids, which are present in both the crystals and the liquid film enveloping them. The nature of the impurities derived from the juice which are responsible for variations in the quality of commercial granulated sugar and its suitability for various uses has been studied. Attention is being given to methods whereby these impurities may be eliminated by improved clarification.

The development of specialties in addition to standard products, such as sugar and sirup, will assist the sugar-cane industry. With this situation in mind, a new product called "cane cream" has been developed. It is a novel and delicious

spread for bread, biscuits, and waffles. Possibilities of the production of other specialties will be studied in order to assist in diversifying sugar-cane products and to enhance the value of the crop.

The cause of the production of "swells" of a non-microbiological nature in canned cane sirup is being investigated, as this has caused considerable loss in the marketing of cane sirup. The production of gas in this case is the result of slow chemical reactions which are now being studied with a view to devising means of prevention.

In the handling and marketing of sweet potatoes, the second largest vegetable crop in the United States, a considerable proportion of the crop, variously estimated at 10 to 20 per cent, is graded as culls and is very inadequately utilized. Consideration is being given to the feasibility of producing starch or starch conversion products, such as dextrins, from these cull potatoes. If this does not prove to be practicable, other possibilities will be considered.

In addition to the many practical problems investigated fundamental research pertaining to rare sugars and sugar derivatives and to methods of sugar analysis is undertaken.

Crop Chemistry

The effect of added inorganic plant food constituents on the chemical composition of crop plants is studied with the purpose of increasing the content of protein and other valuable components in crops. It has thus far been possible to obtain a substantial increase of protein in wheat and in rye. Moreover, the high-protein wheat obtained in these experiments has yielded flour of superior baking qualities. Special attention is being given to the interrelation of soil acidity and crop plants, and to the effect of applying various fertilizers at different stages of growth of the plants. Studies are made of the fundamental principles governing absorption of food by plants and of the relation of soil reaction to the growth of native plants. Analytical methods, both for constituents of the ash of plants and for acidity de-

termination, are studied, and improved upon if possible.

Crystallography

Crystalline substances are immersed in liquids of known refractive index and studied under the polarizing microscope; and data are obtained of value for identification purposes. Crystallographic and optical constants are determined for new and unusual compounds prepared by members of the department staff, and are placed on record along with other physical and chemical constants.

Dust Explosions and Farm Fires

The heavy loss of life and property from dust explosions and fires in threshing machines, grain elevators, cotton gins, flour mills, starch mills, cottonseed-oil mills, and in other manufacturing plants led to an extensive study of methods for preventing such disasters. Through its field work and laboratory tests the bureau devises and perfects appliances and suggests modifications of existing practices and procedures that are helpful in reducing the fire and explosion hazards in various industries.

Dyes

One of the major problems now under investigation at the color laboratory is the application of the Friedel-Crafts' synthesis in the production of dyes. By this process, phthalic anhydride is combined with other materials to form vat dye intermediates.

A study leading to the production of a high grade beta-amino-anthraquinone from chlorobenzene and phthalic anhydride has just been concluded. Other problems under investigation include the production of similar intermediates from naphthalene and phthalic anhydride, and diphenyl and phthalic anhydride. It is believed that the latter will be of special value in view of the fact that diphenyl has recently assumed industrial importance.

Farm Wastes

Lignin is an important component of all vegetation. Up to the present no use has been found for it. In the paper industry it is discarded with the waste liquors from the pulp, and every year millions of tons of lignin are thrown away along with other components of farm waste. Experimental investigations have indicated the possibility of utilizing lignin in the production of eugenol and guaiacol by destructive distillation or by combining it with other materials to form resin-like substances. Other studies have shown that lignin is broken down in the stomach of cows and other animals and that it is decomposed by the action of soil bacteria. These investigations may lead to some correct conception of the chemical constitution of lignin, a problem that must be solved before this material can be profitably employed in the chemical industry.

An investigation of the cellulose obtainable from peanut hulls is almost completed Unfortunately, the essential nature of this cellulose appears to be such that it is not suitable for many of the industries that now use other grades of similar material. The shortage of material from other sources, however, may lead to the practical application of peanut hull cellulose.

It is proposed to give some study to the destructive distillation of farm wastes, such as straw, corn cobs, and corn stalks. In many parts of the country, especially in the West, large quantities of such materials are burned purely for the purpose of getting rid of them. If the distillation could be carried on in properly designed apparatus, valuable industrial by-products could be produced.

Fermentation

The use of molds as industrial agents has been the subject of considerable study. Experiments have shown that one variety of mold will produce gluconic acid from glucose when grown on a solution of this sugar. The laboratory work

on this particular problem has been completed, and production studies are being made on a semicommercial scale.

Gluconic acid may find wide application, as its calcium salt possesses peculiar physiological properties. Calcium gluconate may be injected subcutaneously into human beings without causing necrosis of the tissues, and its lack of taste offers attractive possibilities for oral administration. Experiments on poultry have shown that this salt is of special benefit to hens suffering from calcium deficiency as a result of high egg production.

As the next problem a survey of the action of molds on solutions of xylose is planned. Xylose may be obtained in reasonable quantities from any farm waste, and uses for it would greatly benefit agriculture.

Food Research

The food research division is engaged in a fundamental examination of foodstuffs in all phases of their development, from raw materials to the finished products. The division attacks food problems from the standpoints of the chemist, the mycologist, the bacteriologist, the microscopist, and the economist. It collaborates with the organizations that are dealing with specific food constituents, such as carbohydrates, oils and fats, and proteins. Food problems are studied both in the laboratory and in the field in close contact with the large-scale producers. By this means much useful information is made readily accessible to the public.

Fruit and Vegetable Chemistry

Investigations on fruit and vegetables are concerned with: The determination of organic acids and other chemical components contained in fresh and preserved fruits and vegetables and in various products derived from them, such as fruit juices and jellies; the economical utilization of fruit and vegetable culls; various methods of preserving fruits

and vegetables by drying, by chemical treatment, and by other recognized processes; utilization of cannery wastes; and means for improving the natural color of fruits, vegetables, and their products.

Metals in Foods

Studies are in progress to detect and estimate the normal as well as excessive quantities of the various chemical elements in foods, with special reference to the chronic and acute toxicities produced by the ingestion of foods that have become contaminated with various metals in the progress of their manufacture or preparation, or which contain residues of various sprays or fumigants.

The food research division also tests the quality of all reagent chemicals purchased by the bureau, to ascertain whether they comply with the specifications under which they are bought. A similar service is rendered to the Food, Drug and Insecticide Administration. In the nitrogen laboratory, nitrogen determinations are made on samples of all types, not only for this bureau but for all chemical laboratories of the department that are not provided with the equipment for this work.

Microbiological Investigations

Many changes occurring in food products are of a biological rather than a chemical nature. Problems are constantly arising in regard to the decomposition of raw foods, the deterioration and spoilage of fresh and preserved foods in storage, and the effectiveness of new methods of food preservation and storage. The microbiological flora of the sugar mill, the food factory, and the cannery are being studied with respect to their influence on the finished product. The application of lactic and acetic fermentations in pickle, vinegar, and other industries is being further investigated. The importance of microorganisms in the heating and spontaneous ignition of farm products, and their relation to

the fermentation and molding of grains are also being determined.

Food Microscopy

Histological and microchemical studies of the structure and composition of fruits, vegetables, and grains are made, as a basis for calculating normal and abnormal constituents in their manufactured products, and also for determining the causes of different behavior under varying conditions of manufacture.

Insecticides

Investigations on insecticides are conducted by the insecticide division of the Bureau of Chemistry and Soils in cooperation with the Bureau of Entomology. Compounds are synthesized, and their physical and chemical properties are determined by the chemists. Entomologists then test the compounds upon insects of various classes.

Insecticidal Plants

Rotenone, the insecticidal principle of the root of Derris elliptica, is being studied with a view to ascertaining its constitution so that it may be synthesized. Rotenone is a very potent insecticide for many kinds of sucking and chewing insects. A study is being made in cooperation with a committee appointed by the Insecticide Manufacturers' Association of a chemical method for evaluating pyrethrum flowers. These flowers are now imported to the extent of more than 11,000,000 pounds annually, but no satisfactory chemical assay for them has ever been developed, much to the detriment of the industry. Other insecticidal plants are being investigated for their active principles. Information concerning insecticidal plants is compiled and issued in the form of bibliographies and reviews for the benefit of those interested in seeking new insecticides.

Pyridine Derivatives

Certain derivatives of pyridine of high insecticidal efficacy have been synthesized for the first time, and there is an excellent prospect of developing a commercial process for making from these compounds a contact insecticide that exceeds even nicotine in toxicity. A mixture of crude dipyridyls has lately been put on the market for use as a contact insecticide. This mixture was developed as a result of the cooperative work between the Bureaus of Entomology and Chemistry and Soils.

Aliphatic Compounds

Esters of formic and monochloroacetic acids and compounds analogous to ethylene oxide have been prepared for testing upon insects.

Arsenical Spray Residue

Considerable attention has been devoted to a study of the problem of the removal of arsenical spray residue from apples and pears. A branch laboratory has been established in Wenatchee, Washington, in the heart of the apple-growing section. Tests have been made in cooperation with the Bureau of Plant Industry of the various types of washing machines and washing solutions. A new washing solution in which certain salts partly replace hydrochloric acid has been developed. This improved washing solution is more economical and less injurious to the fruit and to the washing machinery than the hydrochloric acid wash now in general use. Sampling studies have been made in order to determine the proper number of apples that constitutes an adequate sample. Errors in the Gutzeit method have been investigated, and other methods for the determination of small quantities of arsenic have also been studied.

Fluorine Compounds

New fluorine compounds have been prepared for testing against the European corn borer, the codling moth, and other injurious insects. A systematic examination of all fluorides and fluosilicates sold in the United States for use as insecticides has been made, and the results have been published for the benefit of entomologists. The solubility in water of a number of fluorine compounds has been determined for the first time.

New Fumigants

New fumigants of low fire hazard have been developed to take the place of the dangerous carbon disulphide. When used in commercial fumigating vaults a mixture of ethylene dichloride and carbon tetrachloride has been found effective in killing clothes moths, carpet beetles, and other insects infesting stored products. This mixture has a pleasant odor, is nonburnable, relatively nontoxic to man, and is inexpensive. The ethylene dichloride-carbon tetrachloride mixture has become very popular and is not only used on an extensive scale by warehousemen, but is sold in small containers for household use. Ethyl formate has been used in fumigating raisins, and methyl chloroacetate, a fumigant of low fire hazard, is coming into use in place of carbon disulphide. One of the most interesting of the recently developed fumigants is ethylene oxide. This promises to become a successful substitute for hydrocyanic acid gas in the fumigation of foodstuffs, because it leaves no toxic residue in fumigated products as does hydrocyanic acid, and it is practically harmless to man. A method for greatly increasing the insecticidal efficacy of fumigants has been discovered. This method consists in the addition of a small quantity of carbon dioxide to the fumigating chamber.

Physical Properties of Fumigants

The vapor pressure of a number of fumigating materials

has been determined for the first time, and tables have been published showing the maximum weight of fumigants that can be vaporized in a 1,000-cubic foot fumigating chamber at various temperatures. This information has been urgently needed.

Cyanide Investigations

In cooperation with the Bureau of Entomology factors influencing the toxicity of hydrocyanic acid gas to insects under greenhouse fumigating conditions are investigated. Dosages of hydrocyanic acid much smaller than those hitherto recommended have been found effective in controlling insects in greenhouses. A statistical study of the results of cyanide fumigation is in progress. The rate of vaporization of carbon disulphide has been studied, and an apparatus has been devised for its rapid volatilization. The efficacy of naphthalene vapor as a fumigant is being tested.

Arsenical Insecticides

A systematic survey of all arsenical insecticides on the market is being made. Various brands of calcium arsenate are being studied in an effort to ascertain the physical and chemical differences in them that are sometimes responsible for injury to bean plants. New arsenical compounds are being prepared for testing against chewing insects.

Insecticide Literature

A "Review of United States Patents Relating to Pest Control" is issued monthly and distributed to nearly 700 entomologists and others interested in the problems of pest control. Bibliographies and abstracts of insecticide literature are prepared and published.

Hides, Tanning Materials, and Leather

The people of the United States use $2,000,000,000 worth of leather goods annually. The raw materials, that is, hides, skins, and tanning materials, are products of the farm and the forest.

Hides and skins are the base-goods of all leather. Field work and laboratory investigations are conducted to devise more scientifically sound and better methods of handling hides and skins in order to reduce a needless annual waste of millions of dollars worth of these essential raw materials. Causes of the spoilage of hides through poor cure, rot, heating, salt-stains, and the like are determined, and methods of prevention are sought through chemical and bacteriological studies.

Tanning agents are essential in the conversion of hides and skins into leather. Because of the inroads by man and disease upon the forests the supplies of vegetable tanning materials are being gradually depleted. The supply of chestnut wood in particular is being reduced as the result of the blight. The seriousness of this calamity may be appreciated from the fact that more than one-half the domestic supply of tannin comes from this wood. The most economical utilization of tanning raw materials is therefore a very proper subject of study. Possible new sources of both vegetable and mineral tanning materials are sought. The possibilities of establishing and developing foreign tannin-bearing plant products as new domestic crops are investigated, in cooperation with other agencies of the department.

Leather, a product of hides and tanning materials, is a necessity of civilization. The American public pays annually nearly two billion dollars for leather and leather goods. Factors that influence the properties of leather, that cause its deterioration, or that add to its preservation and increase its life of service, are investigated. Methods of tanning and processes of manufacture are analyzed to ascertain their influence upon the quality of the resulting products. The chemical and physical properties of leather and the relative value of leather and leather substitutes are determined. The requirements and specifications for leathers intended for special and unique purposes and uses are determined and defined.

Extravagant practices in the making, selecting, and using of leather and leather articles are pointed out, and methods of utilizing tannery and leather wastes are devised. In collaboration with interested scientific societies and with the industry, chemical and physical methods for the examination and evaluation of tanning materials, leather, leather goods, and related products are improved and modified, and new ones are sought and developed.

Naval Stores

Sixty million dollars worth of turpentine and rosin are produced in the Southern Seaboard and Gulf Coast States annually - and are made into hundreds of millions worth of paints, varnishes, polishes, soaps, sizes, inks, oils, and sealing waxes. Everyone, therefore, has a personal interest in turpentine and rosin.

Researches on the composition, properties, and uses of turpentine, rosin, and other pine tree products, and investigations on the methods of producing and handling these products to improve their quality, to decrease cost, and to eliminate waste, are conducted to help both the producers and the users of the products. Improved methods of production and of handling are demonstrated in the field. Statistics on consumption and available stocks of turpentine are compiled and published annually.

Oil, Fat, and Wax

Progress in the fat and oil industries has been hampered by the lack of knowledge of the major and minor constituents of many of the vegetable oils. Accordingly, the bureau determines and publishes the chemical composition of these substances. Vegetable oils from new sources are examined to discover the purposes they may serve and whether or not it is feasible to produce them commercially. Methods are devised or improved for the investigation of various oils and the products made from them. New derivatives of

the higher fatty acids are prepared, and their chemical and physical properties are determined to ascertain whether or not any of these compounds may serve for the quantitative separation of any of the higher fatty acids from each other. Also, various types of glycerides are being studied to get a more intimate knowledge of their properties. Because of the yearly loss, running into thousands of dollars, suffered by crude oil millers when market conditions force them to hold their stock for a considerable length of time, the keeping quality of various oils has been studied to determine under what conditions the crude oil may be stored with the minimum deterioration.

Paper

A billion dollars worth of paper is used annually in the United States. The factors that determine the utility, serviceability, and durability of paper are investigated, and methods for detecting these qualities are developed, with a view to the more economical and effective use of paper and the conservation of paper-making raw materials.

Means of preventing the rapid deterioration of unexposed brown print paper have been made public. Special attention is given to permanent-record, blue-print, fruit-wrapping, and bale-wrapping papers, and to fiber and corrugated board. An impact tester has been designed and built to obtain information on the probable durability of fiber board. New methods for testing paper are worked out from time to time, primarily to enable analysts to test samples of the many kinds of paper used by the Federal Government.

The Bureau of Chemistry and Soils takes the leading part in developing specifications for paper for printing, for records, for wrapping, and for correspondence.

Protein and Nutrition

The value of feeds and feeding stuffs depends largely on the protein they contain. In the market, feeds are fre-

quently bought and sold on the basis of their protein content. The nutritive value of the proteins in foods and feedstuffs depends chiefly upon their content of the nutritionally essential amino acids. Several proteins in some of our important foodstuffs are deficient or lacking in one or more of these nutritionally essential amino acids. Young animals depending on such a deficient protein in their ration, though supplied in liberal quantity, will make little or no growth. If there is added to this ration, however, some feedstuff, the proteins of which are rich in these amino acids, the proteins of the mixture will be satisfactory for normal growth. An exact knowledge of the chemical composition of the different proteins in foods is therefore essential, not only to know whether they are adequate in themselves, but also to know, when they are deficient, what amino acids are lacking, and what proteins can be added to correct the deficiencies. Accordingly, proteins are isolated in as pure condition as possible from various seeds and natural food products for the purpose of studying their properties and determining their content of amino acids, as a chemical basis for ascertaining their food value. Analytical methods for the study of protein and amino acids are developed or improved. Studies are conducted to ascertain the food value of certain industrial waste by-products that may be utilized for human consumption or as a feedstuff.

Chemical studies are supplemented by feeding experiments with small animals. Food values are estimated by such criteria as rate of growth of young animals, capacity for reproduction and ability of females to nurse and rear their young, and freedom from infections and diseases incident to faulty nutrition.

Vitamins

Experiments are conducted to estimate the quantity of vitamins in different foodstuffs; to extend our knowledge concerning the properties of vitamins; to develop more satisfactory methods for their assay; and to study possible effects

of various commercial processes used in the manufacture of food preparations upon the vitamins contained in the original material. The value of cod liver oil as one of the best sources of vitamins A and D has greatly increased the demand for this product, not only for human consumption but also for incorporation in poultry feed and for stock feeding in general. Special attention is therefore being given to the determination of vitamins in the various preparations and in the different brands of cod liver oil offered on the market. This work is done to develop information for the guidance of officials in the enforcement of the Federal food and drugs act.

Waterproofing and Preserving Fabrics

Simple directions for effective waterproofing and mildew-proofing treatments for canvas, that may be easily and cheaply followed, have been formulated in the bureau. Work on weather-resistant fire-proofing treatments for canvas is in progress; light-resistant treatments for tobacco shade cloth have been devised and demonstrated. It has been shown that sunlight is the most important agency in the deterioration of treated fabrics exposed to the weather and that the addition of certain pigments to waterproofing materials goes far in protecting fabrics from injury by sunlight. Practical methods for testing water and mildew resistance have been developed.

Fertilizer and Fixed-Nitrogen Investigations

The nitrogen-fixation investigations carried on by the fixed-nitrogen research laboratory have been combined with the work of the Bureau of Soils on phosphates, potash, and concentrated fertilizers to form the fertilizer and fixed-nitrogen unit of the Bureau of Chemistry and Soils. These investigations have for their object the discovery and development of processes capable of furnishing cheaper and more efficient fertilizers and fertilizer materials.

Having performed a useful service in aiding the establishment of a synthetic ammonia industry in the United States, this unit is now giving increased attention to fundamental studies on the nature of catalyst surfaces and on the mechanism of their action in promoting gas reactions. Investigations are under way dealing with the rate of formation and decomposition of ammonia; the production of hydrogen from water gas and steam as a function of velocity, temperature, and composition of gas mixture; the crystal structure and thermionic properties of catalysts and catalyst materials; and the effect of contact poisons and promoters on the extent and activity of surfaces.

Numerous technical problems in the production of hydrogen and ammonia are also under investigation. Important projects are: The development and testing of more efficient and stable catalysts, especially for the reaction between water-gas and steam; the removal from hydrogen of carbon monoxide and methane, carbon monoxide by selective oxidation, and methane by absorption in suitable solvents under pressure; and a study of the effect of temperature gradients in catalyst beds during operation.

An extensive program of research is being pursued on the properties of hydrogen, nitrogen, and other gases of industrial importance at pressures up to 1,000 atmospheres and at temperatures up to 400°C. Extensive efforts have been devoted to studies on the composition of compressed gases in contact with liquids. The data so obtained furnish the fundamentals on which much of the design of high-pressure equipment must be based. The highest accuracy is sought in this work, in order that the results may at the same time contribute to a clearer understanding of the nature of the gaseous and liquid states.

Considerable attention is being devoted to an effort to learn the secrets of nitrogen fixation by bacteria. Both the symbiotic and the free-living types of organism are being investigated, with the object of discovering the intermediate steps by which the free nitrogen of the atmosphere is converted into protein. A closely related problem is concerned

with the availability of ammonia nitrogen to various types of plants when bacteria are completely excluded. Certain classes of organic nitrogen compounds are being studied, with a view to bringing free nitrogen into combination at ordinary temperatures and pressures without the aid of living organisms.

Investigations have been completed on a number of other methods of fixing nitrogen. Among these are the formation of aluminum nitride, calcium cyanamide, and sodium cyanide, and the production of nitric oxide as a by-product in the explosion of carbon monoxide-air mixtures.

One of the most important problems with which the unit is concerned is the transformation of the primary products of nitrogen fixation processes into suitable fertilizers. Ammonia or nitric acid must be combined with a suitable carrier, preferably itself a fertilizer. Much effort has been focused on the production of urea from ammonia and carbon dioxide, since its availability to plants, high nitrogen content, and desirable physical properties make this material one of the most promising transformation products of ammonia. The problems that arise in connection with this work are being attacked both in the laboratory and in an experimental plant, and data are obtained to facilitate the design of commercial plants.

In the oxidation of ammonia to nitric acid, an attempt is being made to substitute base-metal catalysts for the platinum commonly employed and to carry out the reaction with oxygen rather than air, in order to facilitate absorption of the nitrogen oxides formed or to obtain the product in the form of liquid nitrogen tetroxide. This liquid has been studied with a view to its utilization in the direct nitration of organic compounds and in the production of nitrogenous fertilizers by absorption in various carriers.

In addition to projects dealing with fixation and utilization of nitrogen, attention is directed to the other essential fertilizer constituents, particularly phosphorus and potassium. Since superphosphate is unsatisfactory as a carrier for ammonia because under these conditions it reverts to the insoluble form, intensive studies are being pursued

with a view to the conversion of phosphate rock into liquid phosphoric acid and finally ammonium or potassium phosphate. The results of the investigations on the volatilization of phosphoric acid have led to the development of two commercial processes. The electric furnace process has been in commercial operation for about six years. and now produces about 75 per cent of the phosphoric acid used in this country for the manufacture of food products and for other industrial purposes. The fuel-fired furnace process has been subjected to intensive investigation on a semicommercial scale during the past five years, and undoubtedly steps will be taken soon toward putting the process into large-scale commercial operation.

An extensive series of investigations of the fundamental reactions that take place in the volatilization of phosphoric acid when phosphate rock is smelted in the presence of carbon or carbon monoxide, with or without the addition of sand or natural silicate, is now being made. A survey of the fluorine content of phosphate rock and other phosphatic materials from widely separated sources has been undertaken.

Much attention has been given to possible sources of potash in this country and to methods for their utilization. As a result of explorations conducted partly in cooperation with the United States Geological Survey, a number of salt deposits and brines, particularly in the arid regions, have been discovered to be potential sources of potash. Searle's Lake, Calif., now yields 20 per cent of the potash requirements of the United States. Numerous other sources have been investigated, such as cement and blast-furnace dusts, distillery and beet-sugar wastes, and the giant kelps of the Pacific coast; and, when feasible, large scale experiments on them have been conducted.

In order that potash may be produced economically from such materials, it is essential that by-products be utilized to share the costs of extraction. Particular emphasis is being placed on this phase of the problem. Thus, a decolorizing carbon (kelp char) and iodine have been produced as by-products from kelp; and in the process recently

developed for the extraction of potash from greensand, the largest potential source so far discovered in this country. several by-products of economic importance are obtained, including ferric oxide, alum, alumina, ammonium sulphate, and glaucosil, an active adsorbent silica.

Methods are being studied and developed for the utilization of phosphoric acid in conjunction with potassium chloride or ammonia to produce the so-called concentrated fertilizers, from which inert material is largely or wholly eliminated. Particular attention is being devoted to the reaction of phosphoric acid to potassium chloride, and the interaction of each of these materials with ammonia and with nitrogen peroxide to form two-constituent fertilizer materials, such as ammonium phosphate, potassium phosphate, and potassium nitrate. These substances offer the advantage that they are among the least hygroscopic of soluble materials, and a mixture of any two of them furnishes a complete, concentrated fertilizer.

Another phase of the fertilizer work requires a study of the chemical and physical properties and of the storage qualities of fertilizer materials and mixtures. The chief problem in this connection concerns the hygroscopic nature of many materials, otherwise excellent, prepared from synthetic ammonia, and means for combating this objectionable property.

The usefulness for fertilizer purposes of waste organic materials and by-products, and methods for converting such materials into desirable forms, are investigated. Efforts are being made to improve the processes used in the production of organic ammoniates; and miscellaneous materials used as soil amendments, such as sulphur and lime, are receiving attention.

Soil Investigations

Soil-fertility investigations necessitate basic chemical research, including chemical analysis of soils, and determination of phosphate, potash, nitrogen, and lime require-

ments, and soil reaction. Studies are made of the changes that take place in plants in the course of a season and in a series of years. Different systems of fertilization are tried on soil of different types, the effect on both soil fertility and the quality of the crops being noted. These experiments require mineral analyses, and, in addition, determination of fats, proteins, starches, sugars, and other organic constituents which determine the quality of crops.

The organic constituents of the complex humus of the soil are isolated, and their origin and transformation in soils as well as their physiological effects on plants are investigated. Also, the effect of borax, manganese, and other rare soil substances on plant nutrition is made the subject of investigation.

Since fertilizers influence the intensity of the green color of plant foliage, color is taken as a basis for ascertaining the nitrogen, potash, or phosphate hunger of plants. A chemical study of the green and yellow plant pigments is under way, with a view to measuring them quantitatively and bringing them under definite chemical control.

The many new nitrogen compounds, both organic and inorganic, now being introduced into the fertilizer trade as a result of the fixation of atmospheric nitrogen, bring new problems of soil fertility, which must be solved by chemically controlled experiments. Special attention is being given to the effects on soils and crops of the more compact fertilizers made possible by these highly concentrated plant foods. Their chemical transformation and their effect on soils are studied in the laboratory; their physiological properties are observed in the greenhouse and in the field.

An extensive system of field experiments with fertilizer salts to discover the best formulas for use in practical agriculture is in operation in more than 50 localities with widely different kinds of soil and crops. The thousands of different fertilizer mixtures tested in this manner are prepared under strict chemical control.

The reaction of soils and its relation to plant diseases is receiving attention.

The properties and chemical composition of soil samples are studied in connection with the classification and mapping of soils. Investigations are conducted on: Methods of analysis; the nature and properties of different parts of the soil, particularly colloidal material; the chemical and minerological changes that take place in the soil as it develops; the influence of different soil constituents on absorption; and the development of acidity. Special investigations are being conducted at present upon: The absorption of acid dyes by soils; peat and muck soils; submerged soils; the physical and chemical properties of soils that are concerned in erosion; and the effect of different soil colloids on plant growth. Analytical, physico-chemical, and petrographic methods are used.

A study of the chemical changes resulting from the activities of bacteria and molds in the soil is carried on parallel with a study of the organisms themselves. Chemical studies of the decomposition of organic matter, nitrate formation, nitrogen fixation, and acidification are closely correlated with studies of the organisms active in these processes.

Soil Survey

To obtain more accurate knowledge of the soils of the United States and to obtain data for use in soil classification and mapping, hydrogen-ion determinations are made of samples representing the more important types of soil of different horizons. The laboratory is equipped for accurately determining the hydrogen-ion concentration by the most approved electrometric and colorimetric methods.

In addition to these various chemical research activities, simple chemical tests are made on soil samples that farmers send to the bureau for aid in solving practical soil-management problems.

Chemical activities of the Bureau of Agricultural Economics are confined largely to the grain division. Here a well-equipped chemical laboratory and a milling and baking laboratory are maintained for the purpose of accumulating data necessary for the preparation and enforcement of the United States grading standards for cereal grains and flaxseed. Methods for grading grain are developed and perfected, so that the various grading factors can be efficiently determined; and special problems that arise in connection with the enforcement of the United States grain standards act are studied. Related activities of the bureau include: Milling and baking studies; protein investigations; rapid oil tests; and moisture investigations.

Milling and Baking Studies

Every crop year many samples of wheat, representing the various commercial classes, are collected, milled, and baked, and compared with samples from other crops. Not only is the quality noted, but also whether the usual grading factors reflect the quality of the wheat. Special milling experiments aimed to study the best methods and conditions for evaluating wheats and flour and to correlate grades of wheat and of flour are conducted. The best grades and types of flour for different kinds of baked goods are determined by baking experiments.

Protein Investigations

Since the grain trade buys wheat on a protein basis, investigations are in progress with a view to the standardization of the Kjeldahl test for making nitrogen determinations, in order that a uniform test may be available to farmers, local buyers, and terminal traders. Experiments are conducted also for the purpose of studying the factors that contribute to gluten quality.

Rapid Oil Tests

Methods for rapidly determining the oil content of seeds, which are especially needed by inspectors, are devised. Methods are being developed for cottonseed, cottonseed meal, cocoa beans, chip liquors, peanuts, soy beans, sesame seed, and flaxseed.

Moisture Investigations

To aid the grain trade inspectors and inspection departments in making moisture tests on whole grains and seed, the methods, technic, and apparatus necessary for such tests are given careful attention.

BUREAU OF ANIMAL INDUSTRY

Chemistry plays a part in practically all the varied activities of the Bureau of Animal Industry in connection with its extensive control work in meat inspection; in the eradication of ticks, scabies, and tuberculosis; in virus and serum inspection; and in the control of animal diseases through regulation of interstate traffic. Chemists are employed and laboratories are maintained for the purpose of insuring the purity of meats and the purity and potency of viruses and antitoxins prepared under Federal inspection. Chemists of the bureau determine the physical and chemical composition and supervise the field and laboratory testing of arsenical, lime and sulphur, and nicotine dips, as well as of disinfectants used in stock yards, stock cars, and for other official purposes.

In addition to control work, chemistry is used in a variety of research work. The chemical composition and nutritive value of various meats and meat products are studied. Changes, such as rancidity in animal fats, are investigated, and efforts are made to devise methods for preventing spoilage. Chemical studies in animal nutrition involving studies of the effect of food not only on animals but on animal

products, such as soft pork, are pursued extensively. Biochemical investigations of bacteria and bacterial products, particularly B. tuberculosis and tuberculin, are carried on, as are chemical investigations of vermifuges and insecticides. Chemical and bacteriological studies of dips and disinfectants are made, with the idea of improving the present methods. Attention is given to the effect of disinfectants on hides and tannery wastes. In determining the effect of injurious plants on animals, the plants themselves are studied, with the object of isolating and identifying the constituents that are responsible for injury to livestock.

BUREAU OF DAIRY INDUSTRY

The Bureau of Dairy Industry makes use of chemistry in its investigations on the nutrition of dairy cows, the physiology of bacteria, the chemico-physical properties of milk, the manufacture of dairy products, and the utilization of dairy by-products. Laboratories with small scale manufacturing equipment are maintained in Washington, nutrition laboratories are located on the experiment farm of the bureau at Beltsville, Maryland, and a commercial factory is operated at Grove City, Pa.

Nutrition of Dairy Cows and Secretion of Milk

A comprehensive investigation of the mineral requirements for milk production is carried on. This includes studies on the calcium and phosphorus compounds of feeds, and the effect of feeding rations deficient in calcium and phosphorus on the composition of the blood, on the milk yield, on reproduction, and on calcium and phosphorus metabolism in general.

The transformation of proteins of the feed into proteins of the milk is the subject of chemical research. This research involves the identification of amino acids of the blood, their quantitative separation, and the changes that take place when the blood passes through the mammary gland.

A special nutrition barn permits extensive feeding experiments under carefully controlled conditions.

Metabolism of Bacteria

Research work on bacteria includes a variety of studies on decomposition as a result of bacterial action, particularly in relation to taxonomic problems and to changes produced in milk by bacterial growth. It includes also studies on the factors promoting and limiting the growth of bacteria, such as the influence of hydrogen-ion concentration, surface tension, salt concentration, and similar factors.

Chemico-Physical Properties of Milk

Investigations are conducted on the chemistry and physics of the heat and rennet coagulation of milk, the conditions that tend to stabilize or destabilize the colloids, the crystallization of lactose, and the oxidation of fats. This work is applied to such dairy problems as the coagulation of evaporated milk in sterilization; thickening of condensed milk; deterioration of butter and milk powder in storage; separation of lactose in condensed milk, ice cream, and in the manufacture of milk sugar; and to the texture and swell of ice cream.

Utilization of Dairy By- Products

Methods are being developed for the more economic utilization of various dairy products, such as skim milk, buttermilk, and whey, which are now utilized inefficiently or wasted. Such problems as the manufacture of casein from buttermilk, the separation of the proteins in a soluble form from whey, and more efficient methods of making milk sugar are considered. The work on by-products includes the extension of old and development of new uses for dairy products. Studies are made on the possible uses of milk powder, milk sugar, soluble albumen, and concentrated sour milk in the

manufacture of confectionery and salad dressing, and in baking.

BUREAU OF BIOLOGICAL SURVEY

Many of the activities of the Bureau of Biological Survey in the control and conservation of wild life, and in propagation of useful species in captivity, are based on chemical research.

Predatory-Animal and Rodent Control

The losses to agriculture, horticulture, forestry, and stock raising caused by injurious rodents and predatory animals call for constant chemical research to test the effectiveness and the cost of application of toxic agents for use in control measures.

In cooperation with the Bureau of Plant Industry, catnip oil has been developed as a lure for trapping various predatory animals of the cat family and has been used with success.

In extensive research in cooperation with the Bureau of Chemistry and Soils, an effective poison for rats, powdered red squill, has been developed. The results of these studies have demonstrated that a powder made from the dried red-squill bulb has an efficient and uniform toxicity for rats and at the same time apparently does not unduly endanger human beings or domestic animals. Several of the factors influencing its toxicity have been determined during the course of the investigations. These experiments have been of material assistance in the production of a uniform and stable squill product. This poison will greatly benefit poultrymen and farmers who hesitate to use some of the commercial rat poisons on account of the attendant danger to domestic animals.

Chemical research is carried on at the bureau's biochemical laboratory at Denver, Colo., and at various places in the field where actual control oper-

ations are tested. In the laboratory, studies are conducted to determine the physical and chemical properties of various poisons in order to ascertain their fitness for use in the field. Pharmaceutical studies determine the lethal dose, the manner and rate of absorption, the rate of elimination, and the general effects of various poisons on different animals. The Bureau of Biological Survey processes and prepares special poisons in quantity for use in control operations throughout the United States. Actual application of the poisons developed at the laboratory is made in the field by district investigators, who carefully observe the acceptance of the various poisons by the different rodents and predatory animals, and note their toxic efficiency under natural conditions.

The chief chemicals employed by the Biological Survey and its cooperators in organized campaigns for mammal-pest control by means of poisoned baits are strychnine and barium carbonate, and in smaller quantities, powdered red squill and thallium sulphate. As fumigants for the control of burrowing animals, carbon disulphide and crude calcium cyanide are extensively used, particularly to complete eradication on areas where most of the rodents have been removed by poisoned baits.

Food Plants of Wild Fowl and Big Game

Chemistry is playing an increasingly important part in determining the suitability of water areas for the growth of wild-fowl food plants. The degree of salinity or alkalinity is often the determining factor in the ranges of aquatic plants. Chemistry also has been called upon by the Biological Survey to assist in solving problems connected with the mortality of wild ducks in western States. Also, attention is given to the effects of poisonous wild plants on deer, antelope, and elk, with the object of determining the constituents responsible for injury to these animals.

Production of Fur Animals

The decrease in number of wild fur-bearing animals has led to the development of the industry of fur farming, which is now supplying many of the pelts for the fur trade. To obtain more sanitary and healthful conditions among these animals, raised in captivity, it has become necessary to apply methods based on chemistry. The Biological Survey has found in studies made at its Fur Animal Experiment Station at Saratoga Springs, N. Y., that the destruction of parasitic vermin on fur animals and in their pens, as well as of any infectious-disease organisms that might be present, can best be accomplished by sterilization. Removal of parasitic worms and protozoa infesting the digestive system of fur-bearing animals depends largely on accurate chemical combinations of the drugs used and on the reactions of these drugs with the different kinds of food eaten. The intensive study being made by the Survey with anthelmintics for fur-bearing animals has necessitated further chemical research on the food requirements of the animals. Infectious diseases of fur-bearing animals and their treatment are being studied in cooperation with the Medical School of the University of Minnesota.

BUREAU OF ENTOMOLOGY

The chief function of the Bureau of Entomology is to discover ways and means for altering the existing environment of insect pests to their disadvantage. The term "environment" is here understood to include the medium in which the insect lives, the host upon which it feeds, and the physiological organization of the insect itself. To comprehend the complex interrelationships of this environment and to alter it intelligently require the aid of all the resources of physics and chemistry. In the following paragraphs the chemical work in which this bureau is interested will be described in general terms.

The physical and chemical environment of the insect may be altered directly by the application of chemical sub-

stances to it or indirectly by cultural practices or by the introduction of parasitic organisms. At present most of the chemical work of this bureau is concerned with the direct method of chemical control.

The selection of one of a number of substances for the control of a particular insect may be accomplished without the help of chemistry, but chemical methods are necessary for a more intimate knowledge of insecticides and their action on insect and host. For example, chemical methods are needed in the determination of the minimum lethal dose of a poison for an insect, its mode and rate of penetration into the insect, its solubility in the juices of the alimentary tract, its distribution in insect tissues, its mode and rate of elimination, and its effect on the physiological processes of insects. The effect of the insecticide on the host is also important, and problems of penetration and distribution of the poison in the host require analytical methods for their solution.

After application many insecticides are exposed to weathering and to various chemical influences that may reduce the quantity of poison available for the insect and may change its chemical composition so as to destroy its effectiveness. Even in storage, decomposition of the insecticide may take place, resulting in greater toxicity to the host or less to the insect. Analytical methods make it possible to estimate the initial concentration and distribution of the insecticide, to follow its rate of disappearance from foliage, fruit, soil, or water, and to study the nature and rate of its decomposition in relation to the chemistry of its immediate surroundings. Chemical and physical changes that may take place when insecticides and fungicides are mixed further complicate and increase the number of chemical problems of the foregoing catagory.

The response of insects to chemical stimuli gives rise to many problems requiring chemical methods for their solution. It is possible by trial and elimination to find compounds that are attractive or repellent to insects, but, again, questions of concentration, volatility, zone and dura-

tion of effective action, and decomposition under particular conditions must be attacked by chemical methods. The fact that the diet of many insects is restricted suggests that the analysis of plants will lead to the discovery of effective attrahents, repellents, or insecticides, or will suggest changes that might be made in the chemical composition of the plant either by cultural practices or by the injection of solutions into the plant.

The study of the biochemistry of the normal insect promises to point out vulnerable spots in its constitution. Chemical investigations on the food requirements of insects are of the greatest importance, for when we know the components of material eaten by insects that are actually utilized by them for maintenance, growth, and reproduction, we may be able to change or remove these components so as to affect the insect adversely. It is desirable, therefore, to study the enzymes, salts, and hydrogen-ion concentration of the alimentary tract, blood, and tissues, as well as metabolism and gas exchange as affected by different foods. The chemistry of the cuticula and intima of insects is important for an understanding of the spreading and penetration of contact insecticides.

Some of the problems being studied by chemical methods in this bureau are listed below.

The toxicity of lead arsenate to the Japanese beetle.

Chemical changes in lead arsenate-sulphur-lime dusting mixtures during storage.

The composition of commercial acid lead arsenate and its relation to foliage injury.

The effect of leaf excretions on the decomposition of arsenicals.

The adherence to foliage of lead arsenate sprays.

The relation of the hydrogen-ion concentration of nicotine solutions to their toxicity.

Factors influencing the toxicity of hydrocyanic acid for greenhouse, bulb, and citrus pests and for their hosts.

Factors influencing the toxicity of oil emulsions for citrus pests and citrus trees and fruit.

Pyrethrum and derris soaps for the Japanese beetle.

The enzymes of the oriental fruit moth larva and the Japanese beetle.

The catalase content of the potato beetle during metamorphosis.

Culture media for the seed-corn maggot, Mexican fruit worm, and beet leafhopper.

Gas exchange of the Japanese beetle and one of its parasites.

Detection and estimation of chitin in insects.

Hydrogen-ion concentration of soil in relation to wireworm infestations.

Naphthalene as a soil insecticide.

Relation of resins of pine trees to bark beetle infestations.

FOOD, DRUG, AND INSECTICIDE ADMINISTRATION

The science of chemistry is essential for the development of facts and principles to guide administrative action in the enforcement of the Federal food and drugs act, the insecticide act, the tea act, the naval stores act, the import milk act, and the caustic poison act

In the enforcement of the Federal food and drugs act, it is essential not only that the existing knowledge of chemistry, bacteriology, pharmacology, toxicology, and medicine be brought to bear on numerous questions involving adulteration of foods and drugs with various ingredients, but also that new facts regarding the composition of a particular food product shipped within the jurisdiction of the act and the effect upon health of the specific adulterants found in that product be ascertained by scientific investigation and experiment, in order that appropriate action may be taken to protect the public from fraud and from harmful adulterants.

Likewise, in enforcing the insecticide act, it is necessary not only to take into account the established facts of chemistry, entomology, and plant and animal pathology

that have a direct bearing on any case under consideration, but also to determine specifically by scientific method what is the exact composition of the particular lot of insecticide material in question and to determine by carefully controlled scientific experiments whether it will kill the insects for which it is sold and whether it will injure the plants on which it is used. Also it is necessary to determine by scientific analysis and experiment what inactive ingredients, if any, may be in each and every shipment of insecticides or fungicides examined under the act.

Food Control Investigations

New methods for the analysis of food products are studied and adapted to meet special needs. Field and laboratory studies are made of the canning of fruits, vegetables, and marine products, and of the methods of producing alimentary pastes, flour, cereals, spices and condiments, vinegar, salad dressings, coffee, dairy products, gelatin, egg products, cacao products, jellies, jams, and other foodstuffs. Similar investigations are conducted on flavoring extracts, beverages, and beverage materials. Fruits, fruit juices, and other natural products, and synthetic chemicals that may be used in the manufacture of extracts, flavors, and beverages are considered also. Authentic flavoring extracts, flavors, beverages, and beverage materials are prepared and analyzed to serve as a basis of comparison for such products on the market. Investigations on the pollution of waters, and radioactivity of waters and drugs are conducted. Methods for the analysis of feeding stuffs are studied, with a view to the improvement of present methods or the development of new procedures to meet changing methods of manufacture. Processes of manufacture of feeds and feeding stuffs are investigated, and many samples of such materials are analyzed to obtain information necessary for their proper control.

Such chemical procedure is supplemented, or in some cases superseded, by microbiological and microchemical investigations. Thus, bacteriological studies are necessary to

solve many of the problems arising in the inspection of water, in the pollution and decomposition of oysters, and in the detection of spoiled stock in canned foods.

The ingredients and the condition of many foods and feeding stuffs may best be ascertained by the use of the microscope. To facilitate this work, the administration has developed special methods for examining canned pork and beans to determine unsoundness, for testing flour, for detecting decayed stock in tomato and fruit products, and for estimating the proportion of shells in cacao products and rice hulls in stock feeds.

Coal-tar dyes are analyzed to determine their suitability for use as food colors.

Drug Control Investigations

Drug control investigations fall into four main groups: Chemical, medical, pharmacognostical, and pharmacological.

The chemical work includes research in the field of drug chemistry, the development of methods of analysis of medicinal products, the examination of samples of drugs and medicines sold in the United States or offered for entry at American ports, and the development of apparatus for various chemical processes. In the development of such apparatus special attention is given to automatic equipment suitable for the extraction of active principles from liquids. Application of these automatic devices is being extended to solid materials. Systematic surveys of the various types of preparations on the market are conducted from time to time. The products now being given special attention are anesthetics, antiseptics, ampuls, galenicals, tablets, malaria remedies, and preparations offered for the prevention or treatment of grippe, influenza, pneumonia, and related diseases. In the work on anesthetics, particular attention has been given to development of methods for purification and preservation of ether and of special apparatus suitable for low temperature fractional distillation of gaseous anesthetics, such as ethylene and nitrous oxide, for the purpose of concentration

and determination of traces of impurities.

The medical work is in the main confined to an examination of the labeling of medicinal products, to determine whether or not the therapeutic representations made are truthful, in the light of the composition as determined by analysis. The basis of judgment is the consensus of present-day medical opinion on the effect of each ingredient of the preparation.

The pharmacognostical work comprises investigations of crude drugs.

The pharmacological investigations include biological assays of a number of drugs for which no satisfactory chemical methods exist. Among these are digitalis, ergot, epinephrine, and pituitary. Official standards for the various drugs for which the United States Pharmacopoeia provides bioassay methods are prepared and distributed. This work was undertaken at the request of the pharmacopoeial revision committee. Among the assay methods recently developed is one for the determination of minute quantities of mydriatic and myotic drugs. Investigations on the physiological effects of small quantities of poisonous substances in foods, such as arsenic on fruits and vegetables that have been sprayed, are in progress almost continuously.

Insecticide, Fungicide, and Caustic Poison Control Investigations

Insecticides, fungicides (including disinfectants), and caustic poisons are analyzed to detect adulterated and misbranded materials, and such investigations as are necessary to bring them into compliance with the provisions of the insecticide act of 1910 and the caustic poison act are conducted.

Naval Stores Control Investigations

Permanent color standards for rosin, prepared by the food, drug, and insecticide administration, accepted by producers and users of rosin, and made the United States standards

by congressional action, are now used for grading rosin sold in this country.

Samples of turpentine and rosin are collected, and analyzed or graded, with a view to keeping adulterated and misbranded naval stores from entering the channels of trade.

The naval stores control unit is authorized under the service features of the naval stores act to analyze and grade naval stores of doubtful purity or grade, when formally requested by an interested person, at a stipulated cost. If samples are taken from such lots by an official inspector in person, a certificate of analysis or grade is issued. If the sample is not taken by an official inspector, the charge is the same but, instead of a certificate, simply a letter giving the results of the analysis is sent to the person who requested the analysis.

Under the service features of the act all the rosin now produced in Texas, Louisiana, and Mississippi, and increasing quantities in Alabama and Georgia, is being graded by the department to the expressed satisfaction of the producers and users of rosin. Users of rosin find that they can work more closely, safely, and profitably with Government graded rosin.

Special Collaborative Investigations

Most of the special collaborative chemical work is done for the Post Office Department and the Federal Trade Commission. Samples of various preparations sold through the mails are analyzed to obtain evidence to assist the Post Office Department in the prosecution of cases under the fraud order law and to assist the Federal Trade Commission in the prosecution of concerns indulging in unfair trade practices. Products examined are those making claims for the cure of catarrh, diabetes, tuberculosis, pyorrhea, cancer, and other diseases, as well as many making extravagant claims for beauty schemes and fat reducers. Packages sent through the mails which are suspected of containing concealed poisons are examined.

The chemical research of the Forest Service is confined largely to the chemistry of wood, in both its fundamental and industrial aspects. The work is carried on at the forest products laboratory of the Forest Service at Madison, Wis. Studies are conducted on the chemical composition of wood; products formed by trees, extractive materials in wood; acid hydrolysis of wood; wood preservation; fireproofing of wood; woodworking glues; and pulping processes.

The chemical composition of wood is investigated to obtain fundamental information for use in connection with chemical utilization methods. The relations between different constituents, and the location of the constituents in the microstructure are studied.

Microanalytical studies of the nature, location, and development within the tissues of products formed by trees, such as oleoresin, gums, and sugars, are carried on to gain a better understanding of natural processes so that the production of timber and by-products can be more effectively controlled by forestry methods.

Of all the constituents of wood, the extractive materials are the most variable in composition and quantity. Both their composition and their effect on wood properties are studied.

Chemical research on the acid hydrolysis of wood is practical, being intended to promote utilization of softwood mill waste by the manufacture of alcohol, sugars, cattle feed, or other products by hydrolytic means. Researches in this field also furnish valuable information on the chemical composition of wood.

Physical chemistry is applied in the study of the structure and properties of wood. This includes investigations on the flow of liquids through wood under pressure or high electrical potential, the true specific gravity of wood substance, the electrical conductivity of wood at different moisture contents, and the equilibria of wood and volatile liquids.

In the problem of wood preservation, subjects of inquiry are the toxic properties of wood preservatives; their action on fungi; their penetrating properties; their chemical stability; and their permanence in the wood.

Wood working glues are investigated, with special attention to means of making casein glues more durable on long-continued exposure, and to improved methods of inspecting casein glues for quality.

Pulp processes are carefully studied, with a view to improving existing processes, developing new methods for increasing pulp yields, and ascertaining means for economizing on chemicals.

Other subjects under investigation are the utilization for pulp of hitherto unused species, wood wastes, and fiber sources other than wood; the determination of the chemical properties of wood and pulps with the object of improving paper-making qualities; means for preventing various sources of industrial wastes, including the decay of wood pulp; and the recovery and economical disposal of waste liquors.

BUREAU OF HOME ECONOMICS

Chemical research supplements the work of the nutrition and textiles divisions of the Bureau of Home Economics.

Food and Nutrition

The value of foods as sources of the different vitamins is being determined. All work on vitamin A has been planned with the idea of improving the technic as much as possible. A study of the relative vitamin A content and calcifying properties of a commercial alcohol-soluble extract of cod liver and a cod liver oil has been completed. The vitamin A content of a commercial cod liver oil concentrate has been determined. Experiments to determine the vitamin A, B, C, and D content of the outer and inner leaves of head lettuce purchased on the Washington market, and also of three samples of honey have been completed. Other studies in progress in-

clude work on the vitamin content of several varieties of spinach, reindeer meat, tea, and watermelon.

Tables on the proximate composition and fuel value of food materials are being prepared for use in dietary calculations. The figures are derived from a study of data compiled from a large number of sources including both published and unpublished material. They will represent as nearly as possible the composition of typical food materials and will provide a basis for reducing some of the errors in dietary calculations.

Textiles and Clothing

The chemical aspects of various textile problems are studied. At present emphasis is being placed upon a series of researches on the different phases of home laundering and cleaning. These include investigations on starching and the effect on various textile materials of the temperatures and reagents employed during washing and ironing.

BUREAU OF PUBLIC ROADS

When all vehicles using the highways had steel tires and were drawn by horses, the highest type of improved road was the macadam or stone-surfaced highway. This type of surface was built of crushed stone spread in two or more courses of uniform thickness over the road-bed and held together by stone dust flushed with water into the crevices between the stones.

The stone dust, as the binding material, was the life of the road. Without it the road would disintegrate into a bed of loose stones. But so long as vehicles had steel tires and moved slowly there was never any lack of the binding dust. If any of it were blown away the loss was soon replaced by the grinding of the steel-tired wheels and the hammering of the horses' hoofs.

With the introduction of the pneumatic-tired automobile these macadam roads rapidly deteriorated. The fast-

moving vehicles withdrew the binding dust and blew it away, and their rubber tires so reduced the wear of the stone that the lost binding material was not replaced. Not only were the best roads of the country rapidly destroyed, but travel was made exceedingly uncomfortable by the dust which hung in clouds over all heavily traveled roads.

At this critical moment the chemist offered timely aid to the highway engineer by proposing the use of bituminous materials (tar and asphalt) as a binder instead of stone dust, and as a result of the change the roads were saved and the dust clouds disappeared.

The bituminous road principle has since been developed scientifically and is now used in roads of many types, some of which are suitable for the heaviest modern traffic. The chemical work of the bureau has to do with tests of bituminous materials. The three principal tests for determining the character of bituminous materials are the penetration, viscosity, and float tests. Although these are physical tests, they were developed to a large extent as a result of the efforts of chemists to evaluate the relative characteristics of bituminous materials.

BUREAU OF PLANT INDUSTRY

The work of the Bureau of Plant Industry calls for chemical investigations in many fields. In addition to work of this kind done in the bureau itself, many activities are carried on in cooperation with the Bureau of Chemistry and Soils, and with other bureaus, State experiment stations, and agricultural colleges.

Many of the investigations in progress in the fruit and vegetable utilization work are primarily chemical. Among these are researches on fruits and vegetables in which a study of the chemical composition of different varieties is made, to ascertain their possibilities for use in canning, preserving, drying, or the making of various food products. Most of these experiments involve comparison of many varieties of a fruit or vegetable grown under controlled conditions so that

the effect of climatic factors upon the composition of the crop as a whole, and also on the chemical composition of the variety is shown. Obtaining such information is a necessary preliminary to developing methods of utilization.

On account of the importance of color in determining the marketability of fruits and vegetables and preserved products derived therefrom, chemical investigations on various plant pigments are being made. Information obtained by these studies aids the horticulturist, since, in plants, hardiness, vigor, and resistance to disease are correlated with pigments. This information will also be of service to canners, who have long desired a definite method for standardizing both the raw material and the finished products of their industry.

Chemistry is utilized in investigations on cereals. Healthy and diseased corn plants are analyzed to ascertain whether starch and sugar are consumed by smut organisms. Chemical studies are made of the juices of wheat plants to determine the relation of the acidity of the cell sap to disease resistance, and the effect of age and environment on the acid content of the juices. Chemical methods are used to discover the susceptibility of wheat to the scab fungus; to determine the inheritance of quantity and quality of gluten and the inheritance of winter hardiness in wheat hybrids; and to show the effect of different rotations and cultural methods on the protein content of wheat. The nature of the organic nitrogen compounds in cereal grains has been studied, and the effect of various constituents of the soil on these crops has been noted. Many different chemicals have been tested under both field and laboratory conditions in searching for more satisfactory means of killing the common barberry.

Biochemical studies in plant nutrition include a study of the effect of light, particularly variations in the daily light period, on internal changes in the plant. The purpose is to ascertain the nature of the internal processes that are responsible for, or are associated with, initiation of flowering and fruiting and other features of development in response to the daylight period. Attention is given to the effect of variation in supply of different nutrients, especially an

insufficient supply, on chemical processes in the plant, such as carbohydrate and nitrogen metabolism.

Biochemical investigations on poisonous plants comprises the determination, isolation, and identification of the poisonous principles.

Chemical studies of sugar plants consist of the determination of sugars and other constituents in both the plant and the juice of sugar cane, sugar beets, and sorgo, together with studies of methods of analysis. All this work requires chemical investigations, such as breeding and selection experiments, disease resistance tests, maturity tests, and tests to show the effect of environment, temperature, and soil.

Chemical methods afford the chief means for measuring metabolic processes in plants, consequently chemistry has entered extensively into the various phases of the work in plant physiology.

Studies have been made of the carbohydrate changes occurring in root crops during development and storage, in order to determine the kind of transformation of carbohydrates taking place under different conditions of storage and also the extent of loss of these food materials from stored roots and tubers through normal processes. This work forms the basis of determining the most favorable conditions of storage.

Considerable chemical work has been done and more is planned or in progress to determine how fruits and vegetables are affected by the various gases, both injurious and harmless, to which they may be exposed during the marketing process. In addition, studies have been made on the changes in the chemical composition of fruits as they ripen. Data so obtained are used, in conjunction with the results of other lines of investigation, in developing better methods for the storage and transportation of fruit.

Researches are being made on the composition of the surface coatings of apples, and on the effect of development, exposure, regional conditions, and storage on the composition of the cuticle. Since these coverings are directly concerned in the susceptibility of apples to storage injury, such ex-

periments may aid in finding means for the prevention of loss during storage.

Investigations are conducted on the chemical changes that take place in the processes of ripening, curing, and fermentation of leaf tobacco; the effects of temperature, moisture, and other external conditions on the progress of these changes; and nicotine content as affected by heredity and environment. Tests are made to disclose the relation of chemical composition to the burning qualities and other properties of tobacco, and to show the specific effects of the several plant nutrients and climate on its chemical composition, growth, and quality.

Chemical work is done incident to the production of perfume and drug plant crops, dealing with the analysis of essential oils, and drug and related products; with the isolation and identification of their constituents; and with methods of commercial production of such materials.

Drying oils obtained from new oil seed crops grown in the United States are analyzed, and the possibilities of commercial production and technological application of these oils are carefully considered. Waste products of various industries and crops are studied with a view to the commercial production and utilization of essential oils, fatty oils, extracts, and similar products.

Diseases of plants, fruit trees, and fruits receive critical attention. Chemical methods are used in a study of the poisons or unbalanced conditions that bring about physiological or nutritional diseases; in a study of the disease-producing organisms; in the preparation of culture media; and in the preparation of sprays and dusts. Tests are made of the various fungicides and combinations of fungicides to obtain comparative data on the effect of their fungicidal powers and injurious properties on the host plant.

Chemical studies of culture media and normal and diseased plant juices have been carried on for many years. A scale has been devised for translating the older terms of expressing acidity in a culture medium into the newer hydrogen-ion terms (1922).

Chemical studies in connection with investigations upon weed control are closely correlated with physiological studies of plants of different species. Experiments have shown that rhododendrons and other acid soil plants that would die in a neutral or alkaline soil will thrive almost as well in a soil acidified with crude aluminum sulphate as in a naturally acid soil of peat and sand.

Chemical investigations are a factor in various other activities of the Bureau of Plant Industry, such as the study of nematocides proper (effect and application); chemotherapy of plants suffering from nemic plant diseases; chemical sterilization of the soil to destroy its nemic fauna; and chemical treatment of seed for the purpose of freeing them from nemic infestations and of preventing nemic attacks while they are germinating.